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TI Lead-free **solder** alloy with improve wetting ability  
IN Munakata, Osamu; Toyota, Yoshitaka; Onishi, Tsukasa  
PA Senju Metal Industry Co., Ltd., Japan  
SO Jpn. Kokai Tokkyo Koho, 4 pp.  
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PRAI	JP 2000-201514		20000703		

AB A Pb-free **solder** alloy is a Sn-based alloy contg.  
**Ga** 0.005-0.2% and optionally **Ag** 0.1-4%. Cu, Sb, Ni, Co,  
Fe, Mn, Cr, and Mo may be added to improve mech. properties, Bi, In,  
**Zn**, may be added to decrease the m.p., and P and Ge may be added  
to prevent oxidn. The alloy has improved wetting ability.

## PATENT ABSTRACTS OF JAPAN

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(21)Application number : 2000-201514

(71)Applicant : SENJU METAL IND CO LTD

(22)Date of filing : 03.07.2000

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TOYODA YOSHITAKA  
ONISHI TSUKASA

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### (54) LEAD-FREE SOLDER ALLOY

#### (57)Abstract:

PROBLEM TO BE SOLVED: To provide lead-free solder essentially consisting of Sn and improved in wettability tough, in the conventional lead-free solder essentially consisting of Sn, wettability has been poor, and soldering defects such as unsoldering, bridges and voids have been generated.

SOLUTION: The lead-free solder alloy of this invention is obtained by adding, by mass, 0.005 to 0.2% Ga to Sn which is the main component, or is obtained by adding 0.005 to 0.2% Ga to Sn as the main component. Further, it is also possible that Cu, Sb, Ni, Co, Fe, Mn, Cr, Mo or the like are added for improving the mechanical properties of the above lead-free solders, or Bi, In, Zn or the like are added for lowering the melting point thereof, or P, Ge or the like are added for preventing the oxidation thereof.

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### LEGAL STATUS

[Date of request for examination]

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[Patent number]

[Date of registration]

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**CLAIMS**

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[Claim(s)]

[Claim 1] 0.005 to Ga0.2 mass %, the lead free solder characterized by the bird clapper from Remainder Sn.

[Claim 2] 0.005 to Ga0.2 mass %, 0.1 to Ag4 mass %, the lead free solder characterized by the bird clapper from Remainder Sn.

[Claim 3] The lead free solder according to claim 1 or 2 in which the aforementioned lead free solder contains an on-the-strength improvement element further.

[Claim 4] The lead free solder characterized by containing Cu and/or Sb below 3 mass % in total as the aforementioned on-the-strength improvement element.

[Claim 5] They are the feature and a lead free solder according to claim 3 or 4 about containing in total one sort chosen from the group which consists of nickel, Co, Fe, Mn, Cr, and Mo as the aforementioned on-the-strength improvement element, or two sorts or more below 0.5 mass %.

[Claim 6] The claims 1 and 2 to which the aforementioned lead free solder is characterized by containing a melting point fall element further, or a lead free solder given in five.

[Claim 7] The lead free solder according to claim 6 characterized by doing in total 0.5-5 mass % content of one sort chosen from the group which consists of Bi, In, and Zn as the aforementioned melting point fall element, or two sorts or more.

[Claim 8] The claims 1 and 2 to which the aforementioned lead free solder is characterized by containing an antioxidizing element further, or a lead free solder given in six.

[Claim 9] The lead free solder characterized by adding P and/or germanium below 0.2 mass % in total as the aforementioned antioxidizing element.

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DETAILED DESCRIPTION

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[Detailed Description of the Invention]

[0001]

[The technical field to which invention belongs] this invention relates to the solder used in case electronic parts are mounted in the solder which does not contain lead, especially a printed circuit board.

[0002]

[Description of the Prior Art] In case electronic parts are mounted in a printed circuit board in electronic equipment, the solder is used, and in consideration of the workability over electronic parts or a printed circuit board, the solder near [ good ] Sn-Pb eutectic [ of soldering nature ] (63 Sn-Pb) is used. Furthermore, since a melting temperature region does not exist but this eutectic solder is solidified in an instant, its time concerning the solidification after soldering is short, and it can perform soldering with the high reliability that there is also very little influence of vibration by conveyer conveyance etc.

[0003] Generally, when it breaks down, or becomes old and is hard coming to use functionally, the disposal of the electronic equipment, such as television, radio, and a computer, is carried out. That to which synthetic resin, and the metallic conductor and solder like a printed circuit board are intermingled on these electronic equipment, and since the metal frame etc. is used further and incineration disposal cannot be performed, the present condition is that the most reclaims land and is discarded.

[0004] By the way, when the printed circuit board of these electronic equipment by which reclamation disposal was carried out is \*(ed) by acid rain in recent years, the lead in solder is eluted and we are anxious about causing the problem on the environment where an underground water is polluted. If the underground water containing this lead is drunk for years, having a bad influence on a human body is known, the movement that an injurious ingredient like lead will be eliminated from the solder used for electronic equipment activates, and lead free solder is called for strongly.

[0005] Lead free solder makes Sn a principal component, adds metallic elements, such as Cu, Ag, Bi, and Zn, and is Sn-0.7Cu (melting point : 227 degrees C). There are some which were further carried out combining the addition metallic element according to the use besides binary alloys, such as Sn-3.5Ag (221 degrees C of melting points), Sn-58Bi (melting point : 139 degrees C), and Sn-9Zn (melting point : 199 degrees C), more than the ternary alloy.

[0006] The wettability at the time of soldering is remarkable, and an above-mentioned Sn-Zn system alloy has it. [ bad ] Since it is a component which is very easy to oxidize, especially when soldering in the atmosphere is taken into consideration, it is remarkable, and generating of dross causes difficulty to soldering and Zn is still more nearly deficient in it also to practicality. Moreover, in order that a Sn-Bi system alloy may present mechanical brittleness peculiar to Bi when there are many Bi additions although generating of the dross in the inside of the atmosphere does not become a problem comparatively, we are anxious about the reliability of the soldered joint section.

[0007] If the stability of soldering in the atmosphere is also taken into consideration, generally the Sn-Cu system, an Sn-Ag system alloy, the Sn-Ag-Cu system alloy which combined the composition element further, etc. are used.

[0008]

[Problem(s) to be Solved by the Invention] As mentioned above, in case electronic parts are mounted in the printed circuit board in electronic equipment, the solder used in consideration of the soldering nature to

electronic parts or a printed circuit board is selected.

[0009] By the way, in the case of soldering, some soldering defects, i.e., non-solder, a bridge, a void, etc. will arise. Generally the solder of Sn principal component is lacking in wettability. Especially a Sn-Cu system alloy has inadequate soldering nature, and since soldering defects occur frequently, wettability improvement is called for strongly. By addition of Ag or Bi, there is an effect in wettability improvement and, generally it is used for it. As the example, although there are solders, such as an Sn-Ag eutectic alloy, and a Sn-Ag-Cu system (Sn-3.5Ag-0.7Cu), a Sn-Ag-Cu-Bi system (Sn-2Ag-0.5Cu-7.5Bi), Ag is a cost side, Bi is the field of mechanical brittleness, and to stop the addition a little is desired. this invention is to offer the solder which has improved soldering nature in the lead free solder of wettability scarce Sn principal component generally.

[0010]

[Means for Solving the Problem] This invention persons found out that the alloy which added Ga raised wettability into the alloy of Sn principal component, and made it complete this invention, as a result of repeating examination wholeheartedly about the means which raises the soldering workability of the lead free solder of Sn principal component, especially the wettability of solder. And also in the case of the alloy containing above-mentioned Ag and above-mentioned Bi, Ga addition gets wet, has an effect on a disposition, and contributes also to reduction-ization of Ag or Bi addition.

[0011] This inventions are 0.005 to Ga0.2 mass %, and a lead free solder characterized by the bird clapper from Remainder Sn, and are 0.005 to Ga0.2 mass %, 0.1 to Ag4 mass %, and a lead free solder characterized by the bird clapper from Remainder Sn.

[0012] if there being no effect in the wettability improvement in solder if fewer than 0.005 mass %, and cutting has more additions of Ga in this invention than 0.2 mass %, its viscosity in a melting solder front face will increase, they will check the fluidity of solder, and will cause difficulty to soldering

[0013] Although Ga addition alloy of this invention has the effect of the improvement in wettability, it is not enough to a part as which a mechanical strength is required. When soldering such a part, any one sort of the metals, such as Cu, Sb, nickel, Fe, Mn, Cr, and Mo, or two sorts or more can also be added as an on-the-strength improvement element which raises a mechanical property. Below 0.5 mass % of the solder whole quantity of the total quantity is [ Sb / Cu and / the total quantity ] desirable about nickel, Co, Fe, Mn, Cr, and Mo, in order for liquidus-line temperature to rise and to check the fluidity of solder, if there are many additions, although any [ these ] metal generates dissolution or an intermetallic compound to Sn and raises a mechanical strength below 3 mass % of the solder whole quantity.

[0014] Moreover, when there is the need of making a soldering working temperature low, as a purpose which suppresses the heat damage of the electronic parts carried in the printed circuit board, and functional degradation, Bi, In, Zn, any \*\* [ one sort of ], or two sorts or more can be added as a melting point fall element. Since there is a limit in the addition when the field of prevention of the difficult pod soldering nature of soldering by oxidization of the melting solder front face of the field of the mechanical brittleness of Bi and In, or Zn is taken into consideration, as for addition of these metals, it is desirable for the total quantity to be below 5 mass % more than 0.5 mass % of the solder whole quantity.

[0015] Any one sort of the antioxidizing elements, such as P and germanium, or two sorts or more can also be added in order to prevent the oxidization at the time of soldering further again. At the time of melting of a solder, these elements are wearing the front face of melting solder by the thin oxide film, intercept contact to the atmosphere, and prevent oxidization of the solder fused at the elevated temperature. If there are many additions of these elements, in order for an oxide film to become thick too much and to check soldering nature, the total quantity of below 0.2 mass % of the solder whole quantity is desirable.

[0016]

[Example] An example and the example of comparison are shown in Table 1.

[0017]

[Table 1]

	組成 (質量%)							特性試験	
	Sn	Ga	Cu	Ag	Sb	Ni	Bi	P	濡れ性試験 ※1
実施例1	残	0.1	—	—	—	—	—	—	良
実施例2	残	0.1	0.7	—	—	—	—	—	良
実施例3	残	0.05	0.7	1	—	—	—	—	良
実施例4	残	0.01	—	—	0.5	—	—	—	良
実施例5	残	0.05	—	0.5	—	0.05	—	—	良
実施例6	残	0.01	0.5	2	—	—	2	—	優
実施例7	残	0.1	0.5	3.5	—	—	—	0.01	優
比較例1	残	—	0.7	—	—	—	—	—	劣
比較例2	残	—	—	3.5	—	—	—	—	良
比較例3	残	—	0.5	1	—	—	—	—	劣
比較例4	100	—	—	—	—	—	—	—	劣
									バレル強度 (MPa) ※2
									18
									31
									45
									19
									33
									73
									52
									31
									45
									45
									18

## [0018] (Explanation of a table)

1: Oxidize to Cu board (a 0.3mm[ in thickness ] x width [ of 10mm ] x length of 30mm) (120 degree-Cx 20 minutes), and consider as a test panel. The flux for soldering is applied to the front face of this test panel, and it is immersed in 260 degrees C into [ various / by which heating maintenance was carried out ] solder, and gets wet to a time-axis, and a curve is obtained. By the so-called wetting balancing method, the zero cross time was measured and it compared about various solders. That to which a zero cross time exceeds A and 2 seconds for what was 2 or less seconds, and exceeds good and 3 seconds for the thing for 3 or less seconds was made into \*\*.

2: Give engine-lathe processing to the casting of solder and it is JIS. The No. 4 test piece of Z2201 is obtained. The tension test was performed at the crosshead speed of a considerable amount by /using the universal testing

machine about 20% of the distance between the gage marks of this test piece, and it asked for the maximum stress, and considered as bulk intensity.

[0019] The lead free solder of this invention is applicable to various product supply forms, such as a rod, a wire, preforming (a ribbon, a pellet, a disk, a washer, ball), and powder (solder paste).

[0020]

[Effect of the Invention] As explained above, a lead component is not eluted in acid rain, but the solder of this invention suits the environmental problem to which importance is attached in recent years, even if the electronic equipment soldered by this solder reclaims land and it is disposed of by failure or old \*\* -ization, since lead free solder is used. Moreover, according to the solder of this invention, in spite of being Sn principal component, it has the outstanding effect that soldering by which whose soldering nature was good and was stabilized is secured.

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TECHNICAL FIELD

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[The technical field to which invention belongs] this invention relates to the solder used in case electronic parts are mounted in the solder which does not contain lead, especially a printed circuit board.

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PRIOR ART

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[Description of the Prior Art] In case electronic parts are mounted in a printed circuit board in electronic equipment, the solder is used, and in consideration of the workability over electronic parts or a printed circuit board, the solder near [ good ] Sn-Pb eutectic [ of soldering nature ] (63 Sn-Pb) is used. Furthermore, since a melting temperature region does not exist but this eutectic solder is solidified in an instant, its time concerning the solidification after soldering is short, and it can perform soldering with the high reliability that there is also very little influence of vibration by conveyer conveyance etc.

[0003] Generally, when it breaks down, or becomes old and is hard coming to use functionally, the disposal of the electronic equipment, such as television, radio, and a computer, is carried out. That to which synthetic resin, and the metallic conductor and solder like a printed circuit board are intermingled on these electronic equipment, and since the metal frame etc. is used further and incineration disposal cannot be performed, the present condition is that the most reclaims land and is discarded.

[0004] By the way, when the printed circuit board of these electronic equipment by which reclamation disposal was carried out is \*\* (ed) by acid rain in recent years, the lead in solder is eluted and we are anxious about causing the problem on the environment where an underground water is polluted. If the underground water containing this lead is drunk for years, having a bad influence on a human body is known, the movement that an injurious ingredient like lead will be eliminated from the solder used for electronic equipment activates, and lead free solder is called for strongly.

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EFFECT OF THE INVENTION

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TECHNICAL PROBLEM

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MEANS

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[0011] This inventions are 0.005 to Ga0.2 mass %, and a lead free solder characterized by the bird clapper from Remainder Sn, and are 0.005 to Ga0.2 mass %, 0.1 to Ag4 mass %, and a lead free solder characterized by the bird clapper from Remainder Sn.

[0012] if there being no effect in the wettability improvement in solder if fewer than 0.005 mass %, and cutting has more additions of Ga in this invention than 0.2 mass %, its viscosity in a melting solder front face will increase, they will check the fluidity of solder, and will cause difficulty to soldering

[0013] Although Ga addition alloy of this invention has the effect of the improvement in wettability, it is not enough to a part as which a mechanical strength is required. When soldering such a part, any one sort of the metals, such as Cu, Sb, nickel, Fe, Mn, Cr, and Mo, or two sorts or more can also be added as an on-the-strength improvement element which raises a mechanical property. Below 0.5 mass % of the solder whole quantity of the total quantity is [ Sb / Cu and / the total quantity ] desirable about nickel, Co, Fe, Mn, Cr, and Mo, in order for liquidus-line temperature to rise and to check the fluidity of solder, if there are many additions, although any [ these ] metal generates dissolution or an intermetallic compound to Sn and raises a mechanical strength below 3 mass % of the solder whole quantity.

[0014] Moreover, when there is the need of making a soldering working temperature low, as a purpose which suppresses the heat damage of the electronic parts carried in the printed circuit board, and functional degradation, Bi, In, Zn, any \*\* [ one sort of ], or two sorts or more can be added as a melting point fall element. Since there is a limit in the addition when the field of prevention of the difficult pod soldering nature of soldering by oxidization of the melting solder front face of the field of the mechanical brittleness of Bi and In, or Zn is taken into consideration, as for addition of these metals, it is desirable for the total quantity to be below 5 mass % more than 0.5 mass % of the solder whole quantity.

[0015] Any one sort of the antioxidizing elements, such as P and germanium, or two sorts or more can also be added in order to prevent the oxidization at the time of soldering further again. At the time of melting of a solder, these elements are wearing the front face of melting solder by the thin oxide film, intercept contact to the atmosphere, and prevent oxidization of the solder fused at the elevated temperature. If there are many additions of these elements, in order for an oxide film to become thick too much and to check soldering nature, the total quantity of below 0.2 mass % of the solder whole quantity is desirable.

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EXAMPLE

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[0017]

[Table 1]

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実施例3	残	0.05	0.7	1	—	—	—	—	良
実施例4	残	0.01	—	—	0.5	—	—	—	良
実施例5	残	0.05	—	0.5	—	0.05	—	—	良
実施例6	残	0.01	0.5	2	—	—	2	—	優
実施例7	残	0.1	0.5	3.5	—	—	—	0.01	優
比較例1	残	—	0.7	—	—	—	—	—	劣
比較例2	残	—	—	3.5	—	—	—	—	良
比較例3	残	—	0.5	1	—	—	—	—	劣
比較例4	100	—	—	—	—	—	—	—	劣
									バルク強度 (MPa) ※2
									18
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[0018] (Explanation of a table)

1: Oxidize to Cu board (a 0.3mm [ in thickness ] x width [ of 10mm ] x length of 30mm) (120 degree-Cx 20 minutes), and consider as a test panel. The flux for soldering is applied to the front face of this test panel, and it is immersed in 260 degrees C into [ various / by which heating maintenance was carried out ] solder, and gets wet to a time-axis, and a curve is obtained. By the so-called wetting balancing method, the zero cross time was measured and it compared about various solders. That to which a zero cross time exceeds A and 2 seconds for what was 2 or less seconds, and exceeds good and 3 seconds for the thing for 3 or less seconds was made into \*\*

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machine about 20% of the distance between the gage marks of this test piece, and it asked for the maximum stress, and considered as bulk intensity.

[0019] The lead free solder of this invention is applicable to various product supply gestalten, such as a rod, a wire, preforming (a ribbon, a pellet, a disk, a washer, ball), and powder (solder paste).

[0020]

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